Technics of Staple Suturing in the Gastrointestinal Tract

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FIVE years ago [5, 6, 7] we described our initial evaluation of the Russian stapling instruments and their American modifications in gastric resections and anastomoses, and in the creation of Heidenhain pouches for studies of gastric secretion. Since then, in a wide range of procedures on the gastrointestinal tract,[8, 10, 11, 12] we have gained considerable experience with these radically advanced American instruments. The instruments have at least as great a field of application in thoracic, particularly pulmonary, surgery, and our experience there is even longer.[4, 5, 8, 9, 11] We have also had some experience with their use in gynecologic procedures, in which they have been widely used in this country. However, the present communication deals solely with their use in surgical treatment of the gastrointestinal tract, for vessel ligation, closure of incisions in bowel wall, closure of bowel ends, sealed transection of bowel, and creation of anastomoses, in various procedures upon esophagus, stomach and bowel.

The Instruments are Principles of Their Use

The instruments which are used for gastrointestinal surgery are the LDS (ligating, dividing and stapling instrument) for double ligation and simultaneous division of omental and mesenteric vessels; the instruments of the TA (thoracic-abdominal) series for closure of incisions and cut ends in the gastrointestinal tract; and the GIA (gastrointestinal anastomosis) instrument for anastomoses, for division of spurs, and for sealed transection of bowel.

The LDS (Ligating-Dividing-Stapling) Instrument is essentially sealed and does not require disassembly for cleaning. It consists of an activating mechanism which is controlled by compression of the handles. A slip-on disposable cartridge contains 15 pairs of staples and a knife blade. The distal end of the cartridge is gently curved in a hook. A channel is created with a curved clamp around the vessel or tissue to be ligated. The lip of the instrument tip follows around the tissue as the clamp is withdrawn, engaging the tissue in the oval window of the instrument. As the handles are compressed, the opening of the hook is closed and all of the tissue within the oval opening thus formed is securely compressed by a staple on each side and divided midway between the staples (Fig. 4A). Compression of the handle is firm and continuous, and the release swift. Hemostasis is equally secure whether a single delicate vein is encompassed in the instrument or a mass of fat and vessels. The instrument cannot accept huge masses of tissue, so that a certain modest delicacy is forced upon the surgeon, a not altogether undesirable effect. When the last pair of staples has been discharged, the instrument will not close, so that one cannot divide tissues without stapling them.

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We have seen or recognize the possibility of the following difficulties: (1) Jamming of staples. In the earlier models, if the handle was partially compressed, and then released, staples tended to jam. A modification, now in production, eliminates this problem. (2) Causing bleeding with the hemostat that is used to create a channel. (3) Causing bleeding by forcing the instrument into an inadequate channel. (4) Avulsing vessels by large movements of the engaged instrument. (5) Avulsing a staple caught on a laparotomy pad, as the pad is being withdrawn.

The TA (thoracic-abdominal) Instruments produce linear suture lines with a double staggered row of staples 30, 55, and 90 mm. in length. The basic instruments consist of an L-shaped frame. The disposable anvil for forming the staples is slipped on the fixed, short limb of the L represented by the lower jaw of the instrument at the end of the shaft. Sliding inside the long limb of the L is a shaft at the end of which is the upper jaw of the instrument, into which the disposable staple cartridge is slipped.

These instruments operate in two steps:

1. Compression of the tissues by turning a wing nut, screwing the shaft down to the appropriate degree, indicated by a vernier on the shaft, until the cartridge and the anvil, with the tissue between them, are separated by the correct distance for proper formation of the staples.

2. Driving the staples home by compression of the handle. Great pressure is not required and the yielding of the staples is easily recognized. With one motion these instruments deliver a double staggered row of 11 (TA 30), 19 (TA 55) and 33 (TA 90) staples.

Before the instrument is closed the pin at the open end of the jaw must be fitted through into the lower jaw-pushed, in the TA 30 and 55, and screwed, in the TA 90. This accomplishes two things:

1. Prevents tissue from being squeezed outside the jaw beyond the staple closure.

2. Assures perfect alignment of cartridge and anvil for precise closure of the staples.

A. For Closure of Cut Ends of Stomach or Bowel. The stomach or bowel is transected with scalpel or cautery, using the edge of the stapler jaw as a guide, and only then is the stapler opened and removed (Fig. 4B). A pink blush or a little bleeding will demonstrate the viability of the 1–2 mm. cuff beyond the staple line. Occasionally this may require a single suture for control. It is to be recalled that the "B" configuration of the staples is noncrushing and fine vessels may actually course through the staples to nourish the tissue beyond.

The vasculature of the bowel must be cleaned away *at the line of transection* since these staples are not designed to control mesenteric or omental vessels which should first be secured with the LDS or manually.

We do not usually, presently, oversew the cut edge but if it is desired, a continuous whip stitch of catgut is all that one need employ to invert the stump. The neat, flattened cut end is much more readily inverted than is any type of manual suture closure. The blue cartridge with 3.5 mm. long staples is less likely to leave an oozing cut edge than the green cartridge with 4.8 mm. long staples, but for a very thick walled stomach the latter should be used.

B. For End-to-End Anastomosis. The two bowel ends are opposed and triangulated. The posterior lips are drawn up by Babcocks or sutures and stapled serosa-to-serosa with the TA instrument. The remaining two sides of the triangle are closed mucosa-to-mucosa with the TA. The ends of the staple suturing lines cross each other (Fig. 1). This is a satisfactory technic for the Billroth I reconstruction after gastrec-

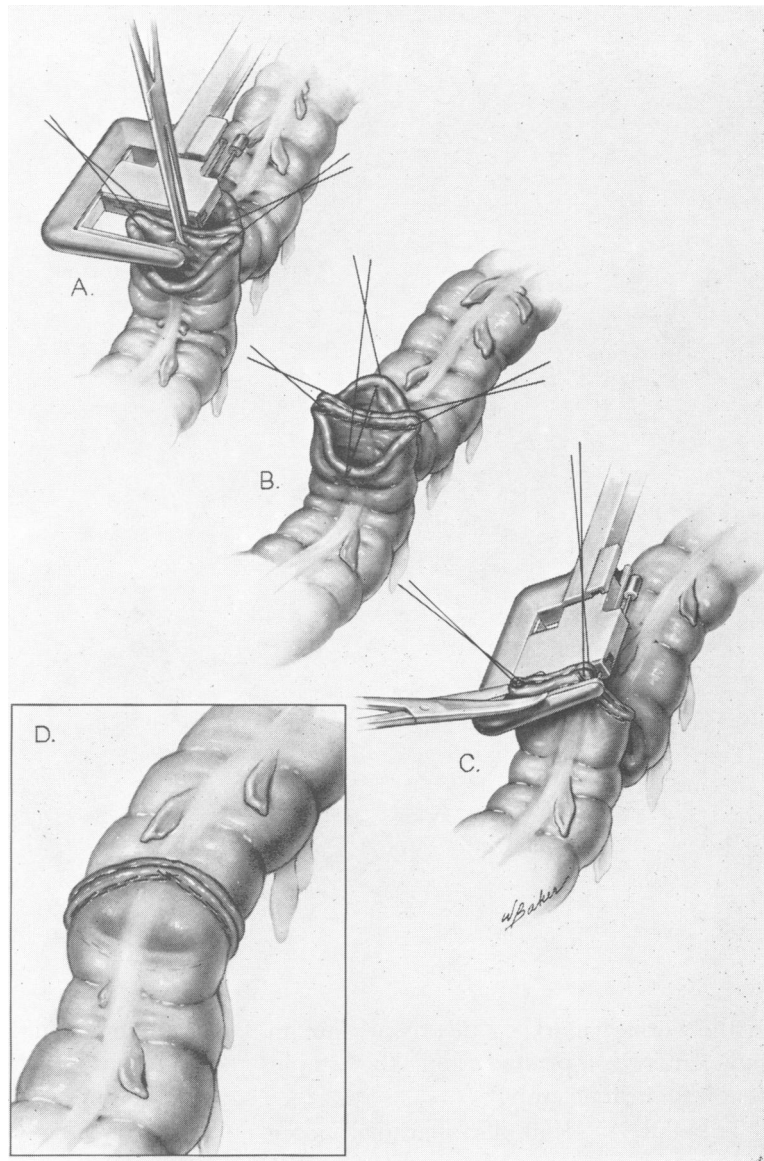


FIG. 1. *End-to-End Anastomosis of Intestine by Triangulation.* (A) The posterior row held by sutures at either end and an Allis clamp in the center, is drawn through the jaws of the TA instrument, the staples driven home and the excess tissue excised, between the stay sutures. (B) The posterior suture line is shown completed and a guy suture placed in the opposed anterior lips. (C) This allows one to place two more suture lines, the bowel edges being apposed mucosa-to-mucosa. (D) The completed suture line showing the overlapping of the staples from one suture line to the next.

tomy (Fig. 5) and we have been satisfied with its use in the colon, particularly in the pelvis.

C. For Closing Linear Incisions (as after gastrotomy, or duodenotomy). Traction sutures or Babcock clamps are placed at the ends of the proposed line of closure and through the middle. Both lips of the incision are drawn into the clamp and stapled; the excess protruding through the clamp is excised (Figs. 6, 7 and 9).

We have known, or recognize the possibility of, the following errors:

1. Failure to insert the pin at the open end of the instrument jaw so the cartridge or anvil is improperly seated and the staple closures are malformed.

2. Failure to screw the instrument down

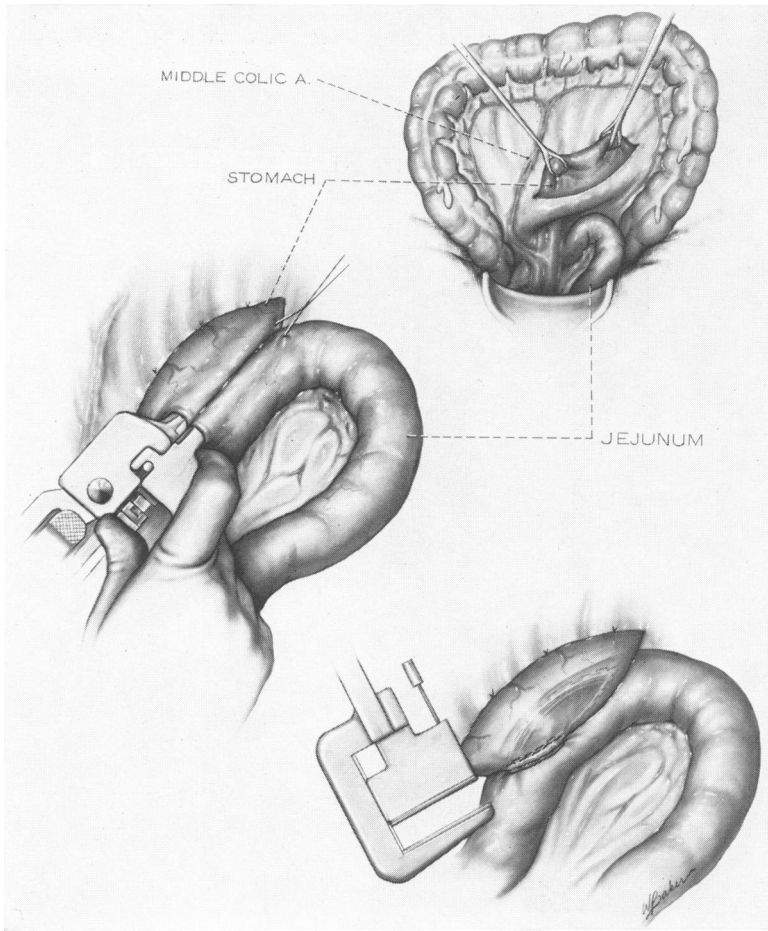


FIG. 2. *Posterior Gastroenterostomy.* The anastomosis is performed serosa-to-serosa with the GIA instrument and the stab wounds resulting from the insertion of the GIA closed mucosa-to-mucosa with the TA instrument. The identical technic would be employed in any lateral anastomosis. The stomach is drawn through the transverse mesocolon and the edges of the mesocolon sutured to the stomach. Parallel stab wounds are made in the jejunum and in the stomach, the limbs of the GIA inserted, the halves of the instrument mated and locked and the three-pronged staple driver-knife assembly pushed home. The final illustration, lower right, shows the completed anastomosis in transparency, and the TA instrument coming off after closing the opening left by the coalescence of the two stab wounds. The closure is mucosa-to-mucosa. No inverting sutures are employed.

to the vernier mark so the tissues are insufficiently compressed and the staples penetrate insufficiently.

3. Failure to clean off a marginal mesenteric vessel in the line of transection so that it bleeds and requires suture after transection of bowel and removal of the clamp.

4. Use of improper cartridges, viz. the white cartridge with very fine and short staples, as for pulmonary vessels, produces a degree of compression which would destroy bowel.

5. Use in diseased or ischemic bowel, or in abnormally thickened bowel as in the untrimmed rim of a colostomy. Clearly a stapled closure is no more likely to succeed than a manual closure if the bowel is devitalized or diseased.

6. Failure to discard anvils and subsequent use of a cartridge requiring a different anvil.

7. Violent compression of the handles to drive the staple, actually warping the instrument.

8. In closing tangential wounds,—as in Heineke-Mikulicz closures, or in closure of the stab wounds after use of the GIA,—failure to draw both lips of the bowel wall well into the instrument results in an incomplete closure and possible leak.

9. Forgetting to squeeze the handles so the tissue is merely compressed, not stapled.

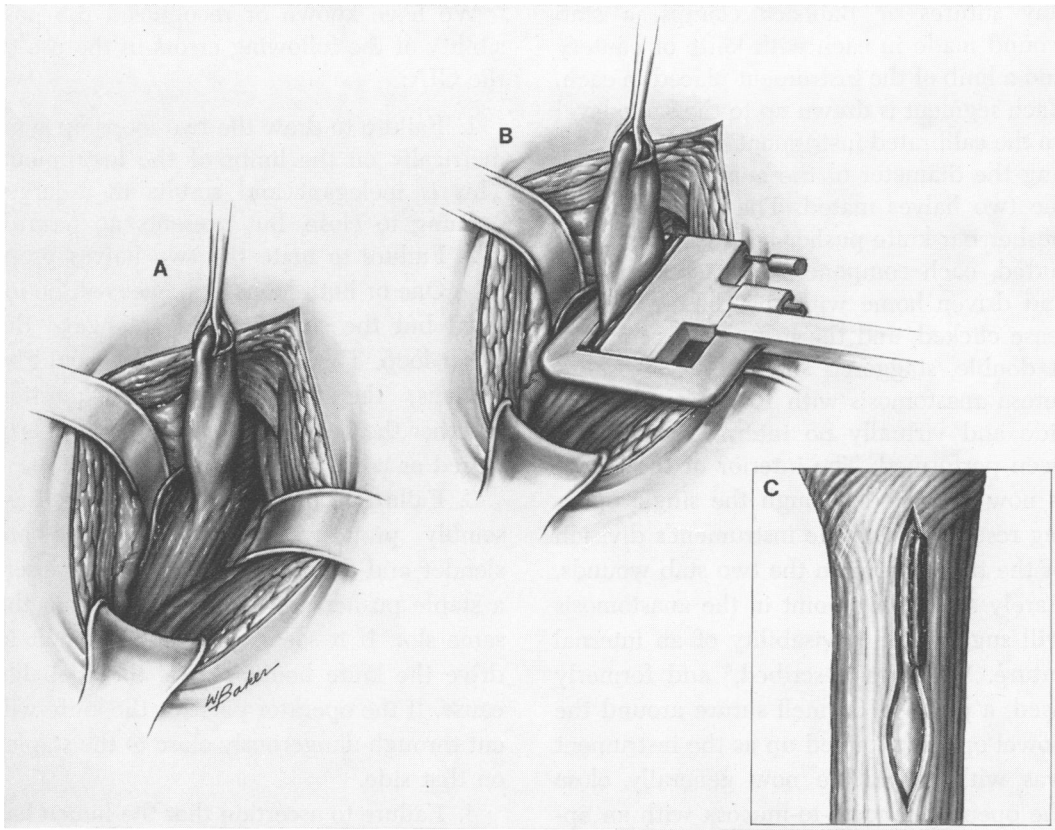


FIG. 3. *Excision of Zenker's Pharyngeal Diverticulum.* (A) The diverticulum has been dissected down to its neck until its emergence from the pharyngeal musculature is clearly seen. (B) It is held lightly with forceps to avoid drawing the esophagus into the clamp and to avoid stapling tissue which is on the stretch. (C) The staples having been driven home and the diverticulum excised, the opening of the pharyngeal musculature is continued distally as a pharyngeal myotomy. (The same technic may be used for an epiphrenic diverticulum and for some Meckel's diverticula.)

The GIA (Gastrointestinal Anastomosis) Instrument

The instrument consists of two portions each with a slender protruding limb one of which is graduated in centimeters—up to 5. One limb accepts the disposable metal anvil, the other the disposable plastic cartridge which carries two double rows of staples, 8 to each row, and a central slot. The cartridge carrying half is slotted to receive a three pronged disposable assembly consisting of two lateral pusher bars to form the stape closure and between them a knife to cut the tissues between the two double staple rows. The three prongs must be inserted in the corresponding slots of the cartridge. The limbs are inserted, the instrument halves are mated until they lock and the three pronged assembly is driven home. The division of the bowel between the double staple lines stops short of the last staples. The pusher assembly is withdrawn. Pressure upon the snap release unlocks the two halves which can now be removed.

A. For Lateral Anastomoses in the Gastrointestinal Tract (as in a classic, retrocolic, posterior gastroenterostomy (Fig. 2). The two segments are juxtaposed by

stay sutures or Babcock clamps, a stab wound made in each with knife or cautery and a limb of the instrument placed in each. Each segment is drawn up to the same level on the calibrated instrument limb,—controlling the diameter of the anastomosis,—and the two halves mated. The three pronged pusher bar-knife-pusher bar assembly is inserted, each component in its proper slot, and driven home with the thumb, the release clicked, and the instrument removed. A double, staggered suture line, serosa-to-serosa anastomosis with 16 sutures on each side and virtually no internal flange, has been performed. The interior of the bowel is now inspected through the single opening resulting from the instrument's division of the tissue between the two stab wounds. Rarely a bleeding point in the anastomosis will suggest the advisability of an internal suture. We have described,[6] and formerly used, a prefixed Connell suture around the bowel opening, pulled up as the instrument was withdrawn. We now generally close the opening mucosa-to-mucosa with an application of the TA instrument, usually TA 55. To be sure that both lips are pulled through the instrument for the entire length of the closure, traction is employed by sutures or Babcock clamps at the ends and middle of the proposed staple suture line.

We have known or recognized the possibility of the following errors in the use of the GIA:

1. Failure to draw the two loops up symmetrically on the limbs of the instrument. This is inelegant and results in a larger opening to close, but presents no hazard.

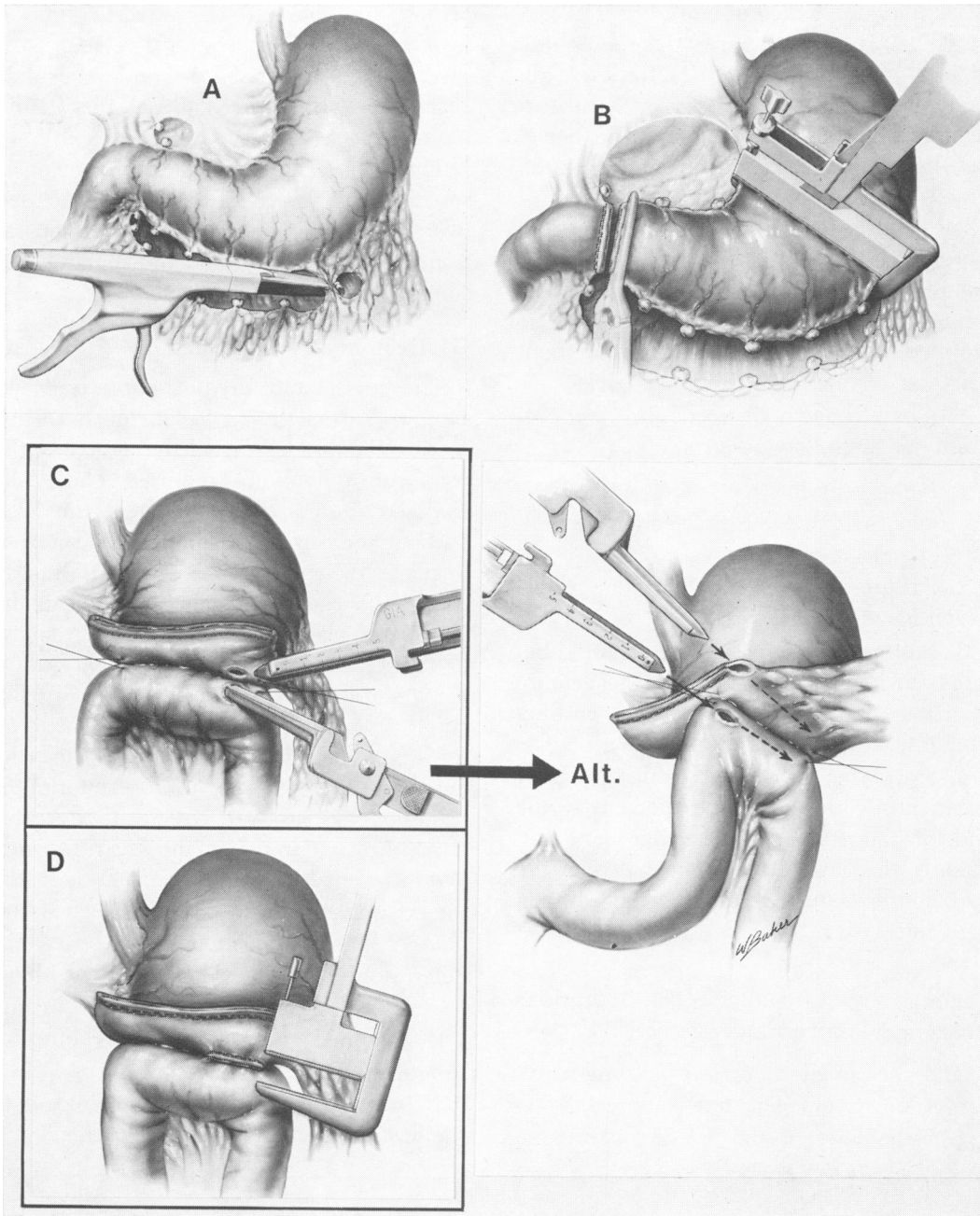
2. Failure to mate the two halves properly. One or both loops of bowel will be incised but the staples will not engage the lower loop. The defect produced would be obvious; there should be no question whether the instrument halves are properly mated or not.

3. Failure to insert the three-pronged assembly properly. The three stems are slender and flexible. It is possible to insert a staple pusher and the knife blade in the same slot. If it seems unusually difficult to drive the knife home, this is the probable cause. If the operator persists, the knife will cut through dangerously close to the staples on that side.

4. Failure to ascertain that the lumen has been entered (essentially only with esophagus or stomach) and passing the instrument limb submucosally.

5. In Finney pyloroplasty, and functional end-to-end anastomoses, failing to secure serosa-to-serosa apposition so that (a) in-

FIG. 4. *Partial Gastrectomy and Billroth II Reconstruction.* (A) The LDS instrument is shown clearing the greater curvature. With each compression of the handles, two staples are placed a quarter of an inch apart and the tissue encompassed in the instrument simultaneously divided. (B) The duodenum has been divided along the edge of the TA-55 after the staples have been driven home, and the gastric stump secured with a clamp. The TA-90 has been placed across the stomach at the desired level. (C) The proximal portion of the stomach has been sealed by the double staggered staple row applied by the TA-90. No oversewing is required of either gastric or duodenal stump although occasionally a bleeder in the closure may justify a single suture. Shown is a Billroth II reconstruction of the anastomosis on the posterior surface of the stomach. Stab wounds are made in the stomach and in the jejunum for insertion of the two limbs of the GIA instrument. Concern is often expressed about the viability of the portion of posterior gastric wall between the stab wound and the staple closure of the gastric stump. We have not seen any recognizable vascular embarrassment of this tissue and have had no leaks. (D) The two stab wounds have been converted into a single opening by the knife of the GIA and this opening has now been closed mucosa-to-mucosa with the TA instrument. No sutures are required. Shown also is an alternate method, for performing the gastroenterostomy, by excising a corner of the staple closure line in the stomach and passing one blade of the GIA along the posterior wall of the stomach parallel to the greater curvature and passing the other in a similar direction into the jejunum. The opening left by the division of the tissue between the two stab wounds is closed as in D. It will be noted that the GIA is graduated in centimeters so that the size of the anastomosis can be controlled.



terposed fat prevents a secure closure or (b) vessels in it bleed.

6. Failure to seat the anvil properly may result in malformed staple closure.

7. If the tissues are abnormally thick, the knife may cut through the two bowel walls while the staples do not securely grasp them.

B. For Bowel Transection. We now rarely transect bowel in any other way than by application of the GIA whatever our

ultimate plan for the cut end (Fig. 11A). A window is created against the mesenteric edge of the bowel, a limb of the GIA applied on either side of the bowel, the instrument locked and driven home. The bowel has been transected, each end sutured closed with a staggered, double line of staples. If the end is to remain closed, no more need be done. In any case, until anastomosis or colostomy or ileostomy is performed, the stump is dry and clean, may be dropped back into the abdomen without dangling clamps or enveloping packs.

We have known or recognize the possibility of the following errors:

1. Failure to fit the bowel within the instrument, so that the transection and suture line are incomplete.
2. Failure to clear a marginal vessel which is cut and bleeds.
3. Mal-use of the instrument as noted before—(a) inaccurate mating, (b) inaccurate insertion of the three-pronged pushing assembly.
4. Since the instrument is designed for anastomoses, the knife does not cut to the end of the stapled suture line and frequently this last bit of tissue between the two double suture lines must be snipped with the scissors.

Technics Involved in Specific Operations

Pharyngeal Diverticulectomy (Fig. 3)

The neck of the liberated pharyngeal diverticulum is grasped and compressed between the jaws of the TA-55 instrument. Strong traction on the diverticulum is avoided. Following staple discharge, the diverticulum is excised beyond the staple suture line, using the blade of the TA instrument as a guide.

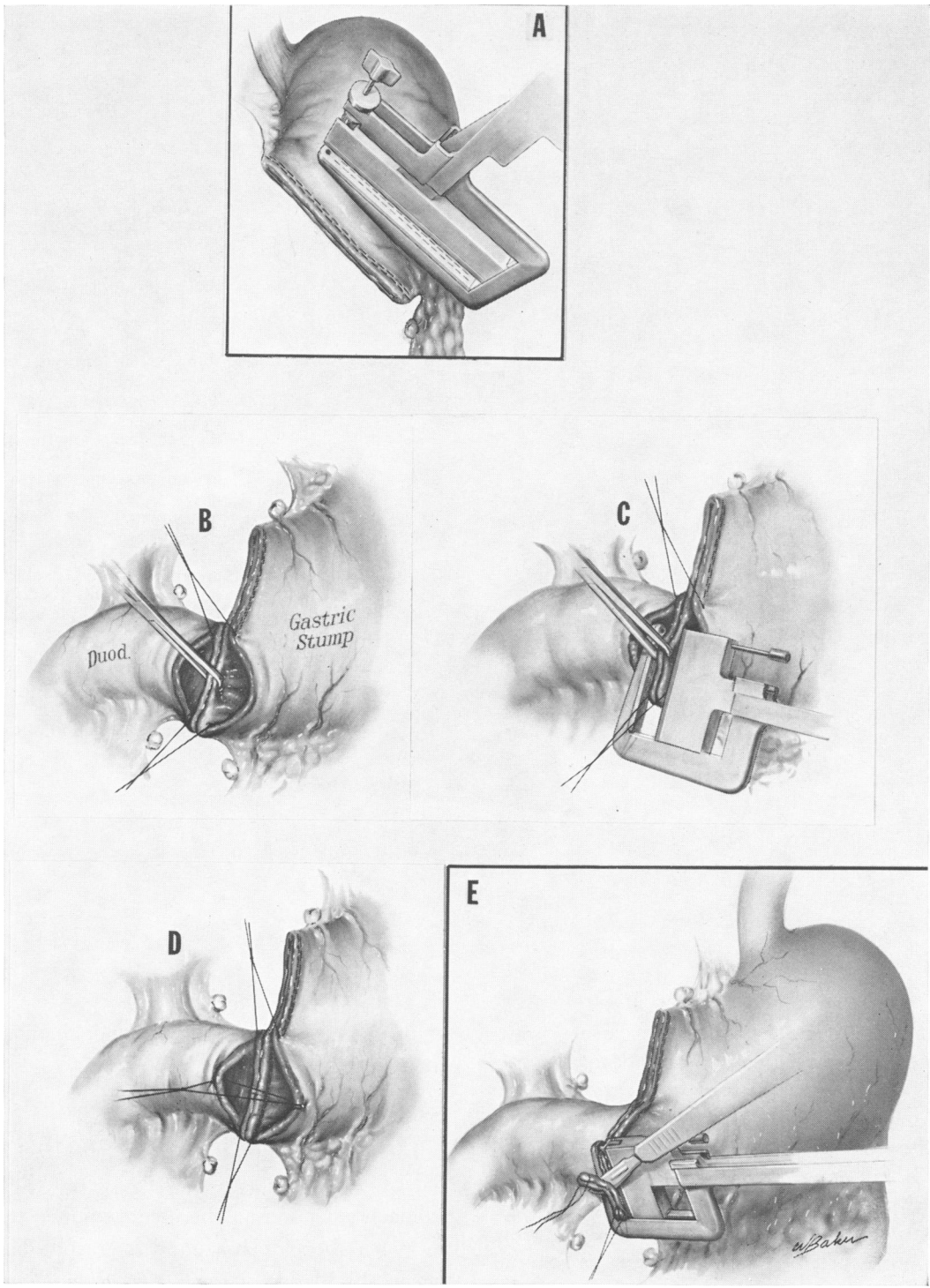
The pharyngeal musculature, previously separated by the diverticulum, is not closed over the suture line. The muscular separation is rather continued downwards for some 5 cm. as a myotomy.

Gastrectomy (Figs. 4 and 5)

The lesser and greater curvatures are prepared using the LDS. Obviously in dissecting the duodenum off the pancreas, the usual suture ligation is required. The TA-90 is placed across the stomach at the level and angle desired, the holding pin screwed in place, the instrument screwed tight, staples descharged, stomach cut between the TA-90 and clamps on the specimen, the jaw of the TA-90 acting as a guide. Suture inversion of this flattened closure with a whip stitch of catgut is optional. The gastroenterostomy for a Billroth II (Fig. 4) may be antecolic or retrocolic, to the anterior or posterior gastric wall, along the greater curvature or parallel to the gastric stump. We have not seen pallor or cyanosis in the intervening strip of stomach between suture lines of the gastric stump and the gastroenterostomy, and in a long experience have never seen necrosis or leakage occurring. The combined stab wound is closed mucosa-to-mucosa with the TA-55.

If it is desired to tack the jejunum over the gastric stump, this is done with silk.

FIG. 5. *Partial Gastrectomy, Billroth I Reconstruction.* (A) The gastric vasculature has been divided with the LDS and the stomach closed with the TA-90 and transected along the edge of the instrument. (B) The duodenum has been transected without being stapled, and has been brought up to the stomach. A corresponding portion of the gastric staple closure has been excised. The anastomosis will be made by triangulation. The posterior row, which is inverting, is defined by traction sutures at either end and a clamp in the midportion. (C) The posterior lip is drawn up in the TA instrument which is then driven home and the protruding edges of stomach and duodenum excised on the edge of the instrument. (D) The posterior row has been completed, the guy sutures left intact. An additional traction suture is placed through the middle of the remaining two thirds of the circumference. (E) Seen are the remaining portion of the gastric stump, the completed staple closure of the anastomosis overlapping it and the third side of the anastomosis now being completed by excision of the excess tissue protruding through the TA clamp after the staples have been driven home. No inversion is required.



The duodenum is closed mucosa-to-mucosa with the TA-30 or 55, and once more inversion of this closure is optional.

If a Billroth I reconstruction is to be performed, the duodenum is transected without being stapled and a corresponding

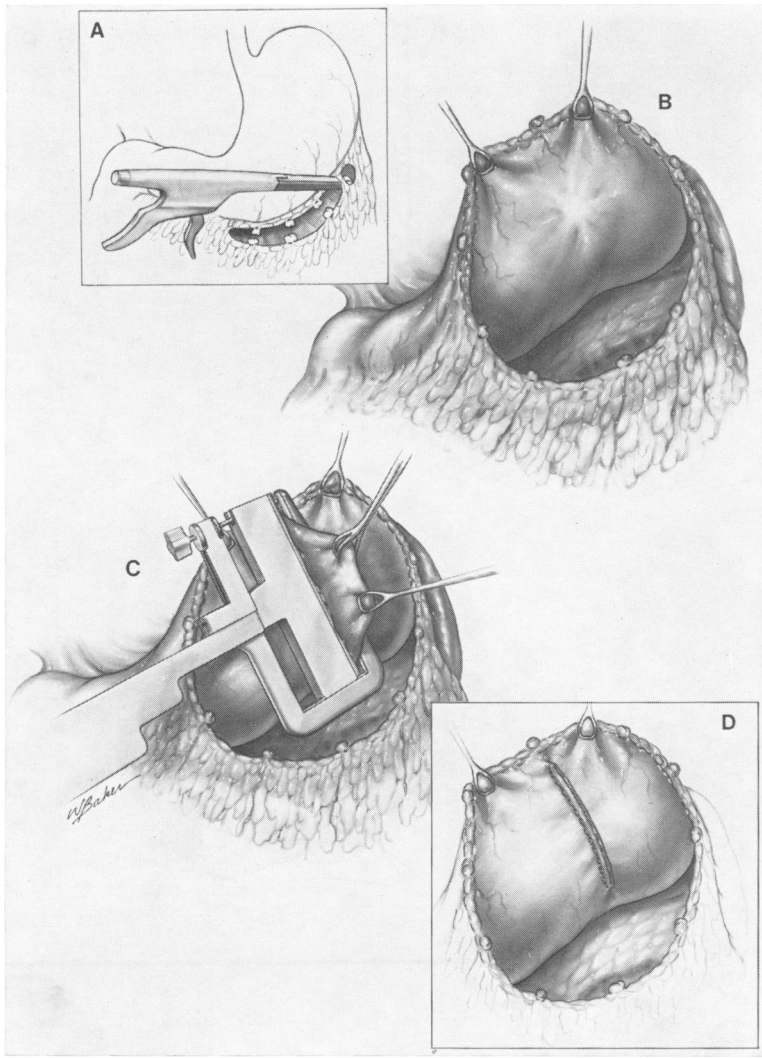


FIG. 6. *Excision of Gastric Ulcer.* (A) A portion of the two curvatures is cleared with the use of the LDS. (B) Shown is an ulcer in the posterior gastric wall. (C) The ulcer and a good bit of stomach are drawn up through the jaws of the TA-90 extending almost from curvature-to-curvature, the instrument compressed, the staples are driven home and the specimen is excised on the instrument. (D) Shows the resultant slight puckering effect. No sutures are required and a subsequent gastrointestinal x-ray shows no recognizable deformity of the stomach and only the double line of staples to indicate that an operation has been performed. The specimen has an elliptical shape.

length of the stapled gastric closure is excised. Triangulating end-to-end anastomosis is performed with three applications of the TA-55. The posterior row is inverting, the other two everting (Fig. 5).

It is our impression, and that of others, that stapled anastomoses function sooner than those manually sutured and, in view of our experimental comparisons of manual and stapled anastomoses,[5] this is not to be wondered at. Stapled anastomoses at every stage show minimal reaction at a time when manual anastomoses are ragged, hemorrhagic, and edematous.

Excision of Gastric Ulcer (Fig. 6)

The greater curvature is prepared with the LDS and the lesser sac is entered. The stomach surrounding the ulcer is pulled up by two Babcock clamps and is grasped between the blades of the TA-90 instrument. Following closure of the blades and staple discharge, the ulcer with surrounding nor-

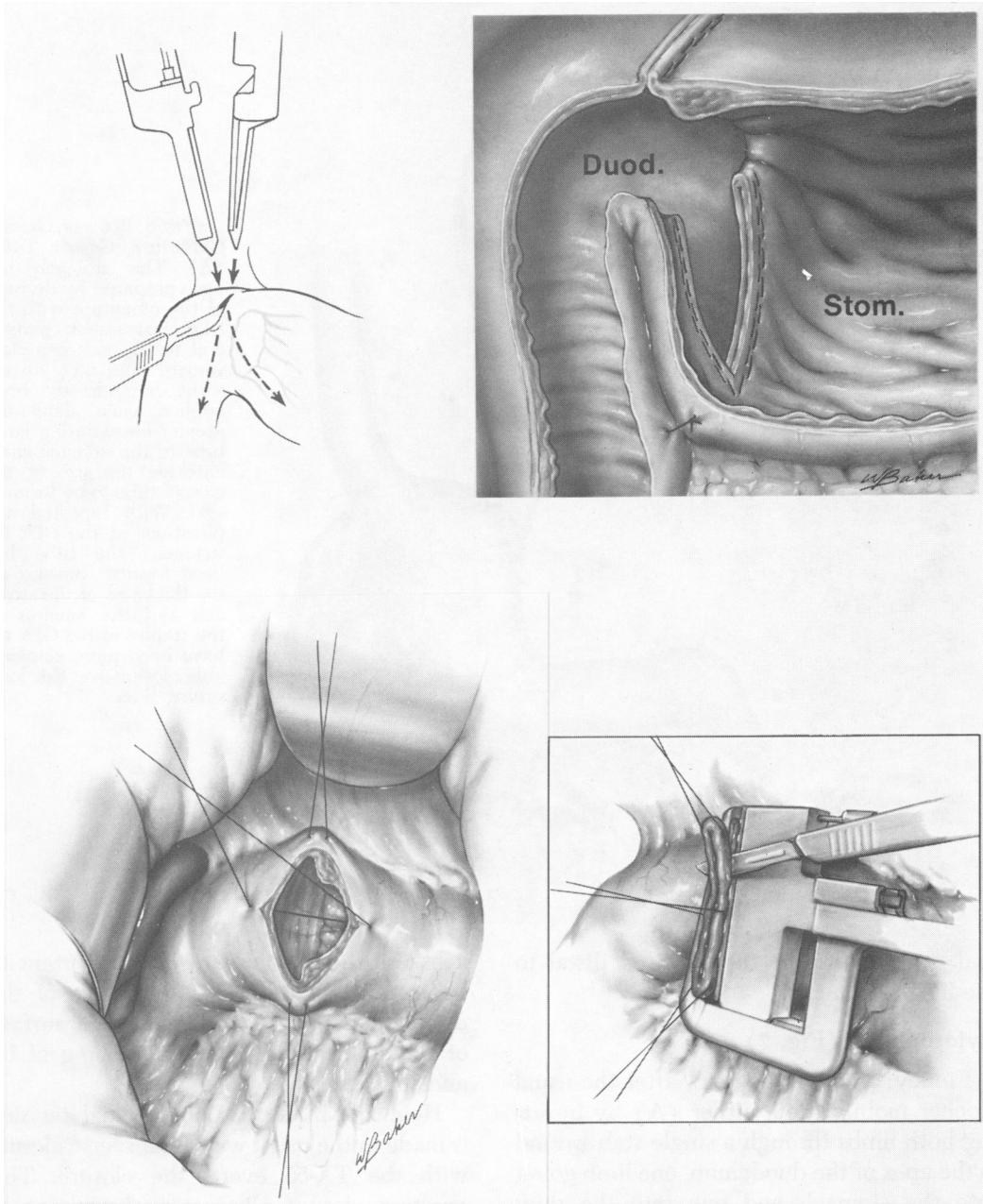


FIG. 7. *Pyloroplasty.* Above, *Finney Pyloroplasty.* The usual mobilization of the duodenum is performed and a single tacking suture placed to hold duodenum and stomach together as shown. The limbs of the GIA are inserted through a single stab wound just beyond the pylorus, the halves are mated, locked together and the instrument is activated. The stab wound is then closed with the TA instrument, mucosa-to-mucosa, in a line transverse to the axis of the duodenum. A single suture anchors stomach-to-duodenum. The cutaway diagram shows the large stoma, with the double staggered line of staples on either side, and the everted stab wound closure. Below, *Heineke-Mikulicz Pyloroplasty.* The standard longitudinal incision is made, perhaps a little longer than shown. The traction sutures at either end draw the opening into a transverse diamond and the sutures placed between the original corners of the incision draw the wound so it is now transverse and the lips can be drawn into the TA-55 instrument which is compressed and activated, driving home the staples. The protruding excess tissue with the guy sutures is shown being excised. No sutures are required.

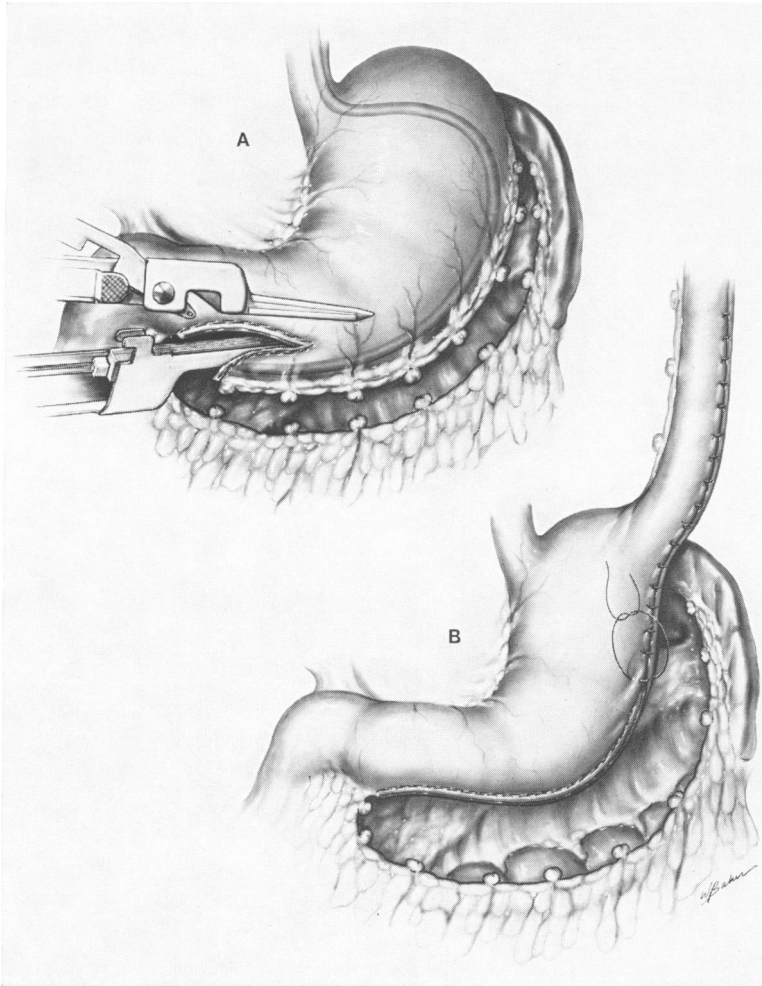


FIG. 8. *Reverse, Greater Curvature, Gastric Tube.* (A) The stomach has been prepared by division of the omentum with the LDS instrument, peripheral to the gastroepiploic vessels. The GIA instrument has already been applied once along the greater curvature, a large tube in the stomach guaranteeing the size of the gastric tube to be formed. (B) With repeated applications of the GIA instrument the tube has been formed. Because of the thickness of the stomach and the fineness of the staples in the GIA we have been more comfortable closing over this long suture line.

mal stomach wall is then excised distal to the TA instrument.

Pyloroplasty (Fig. 7)

Finney: The GIA is used, after the usual Kocher mobilization, either (A) by inserting both limbs through a single stab wound in the apex of the duodenum, one limb going into the stomach and one into the duodenum, the stab wound being then closed with the TA-55, or (B) through separate stab wounds in the second portion of the duodenum and in the gastric antrum, the two limbs going up to the pylorus. In either case, we place a single suture at the lower end of the fusion between the stomach and the duodenum to protect the suture line against pull by the weight of the filled stomach. With either method it is important to be certain that the serosal surface of the duodenum is turned to the serosal surface of the stomach, without intervening of fat and its vessels.

Heineke-Mikulicz: Longitudinal incision is made in the usual way. Transverse closure with the TA-55 everts the closure. This everting closure eliminates obstruction at the pyloroplasty and resultant inadequate gastric emptying the *bête noire* of vagotomy and pyloroplasty.

Reverse Gastric Tube (Fig. 8)

A reverse gastric tube of the Gavriliu-Heimlich type is readily constructed by using the GIA in serial applications to create the greater curvature tube formed

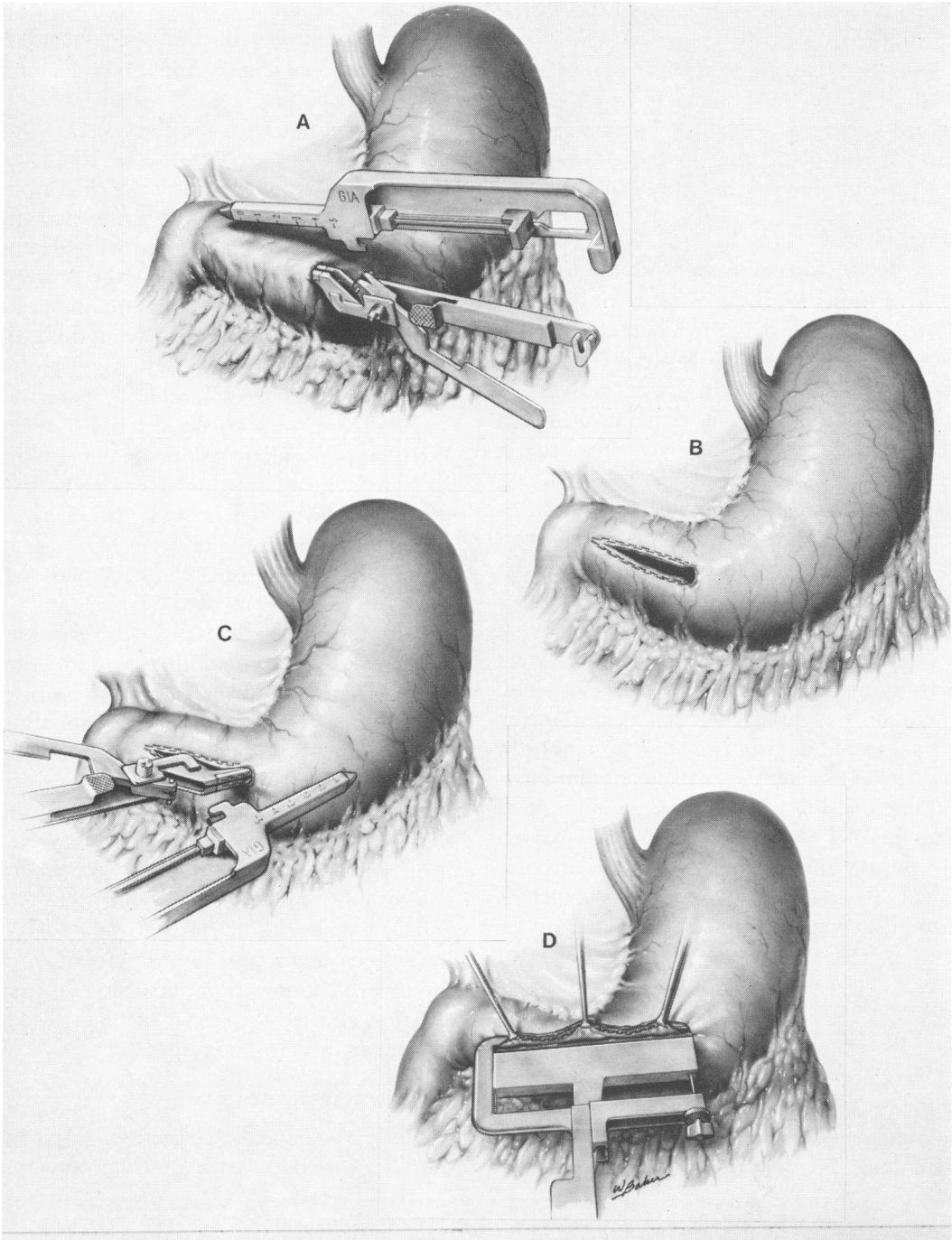


FIG. 9. *Emergency Gastrotomy.* During an emergency gastrotomy, in the search for a source of upper gastrointestinal hemorrhage, bleeding from the cut stomach wall is often troublesome and may tend to interfere with the location of the source of the mucosal hemorrhage. (A) One blade of the GIA is placed within the stomach, the other blade outside of it. (B) When the instrument has been activated, a stapled, dry, 5 cm. incision results. (C) If one wishes, a longer incision can be made by reapplying the instrument in the other direction. We tend to use the shorter staples of the P-GIA (pediatric) for this purpose since only a single layer of stomach is being stapled. (D) If the clinical situation is such that the gastrotomy incision is to be closed, the edges are drawn through the jaws of the TA instrument for an everting mucosa-to-mucosa closure.

on an Ewald tube. Stomach and the gastric tube are left with two rows of staples and a mucosa-to-mucosa suture. The fine staples of the GIA in thick stomach, and the long suture line, have seemed to us to argue for the wisdom of turning in the suture lines with a continuous whip stitch of catgut.

Gastrostomy

A Beck-Jianu tube gastrostomy can be fashioned in the same way as the reverse gastric tube. We have not had occasion to perform a Janeway gastrostomy, but if a large rubber tube is inserted transversely into the stomach from a point near the lesser curvature, a Janeway-type gastric tube can be constructed on it by placing the GIA behind the tube just as one places it along side the rubber tube in the creation of a reverse gastric tube.

Gastrotomy (Fig. 9)

As neat a use of the GIA as any is in performing a gastrotomy, as in emergency operation for gastric bleeding. One limb is placed inside the stomach, one limb outside and activation of the instrument produces a 5 cm. incision with both edges sutured so that there is no bleeding from this source to confuse the picture. For this purpose, since only a single thickness of stomach is sutured, we employ the P (pediatric) GIA with shorter staples.

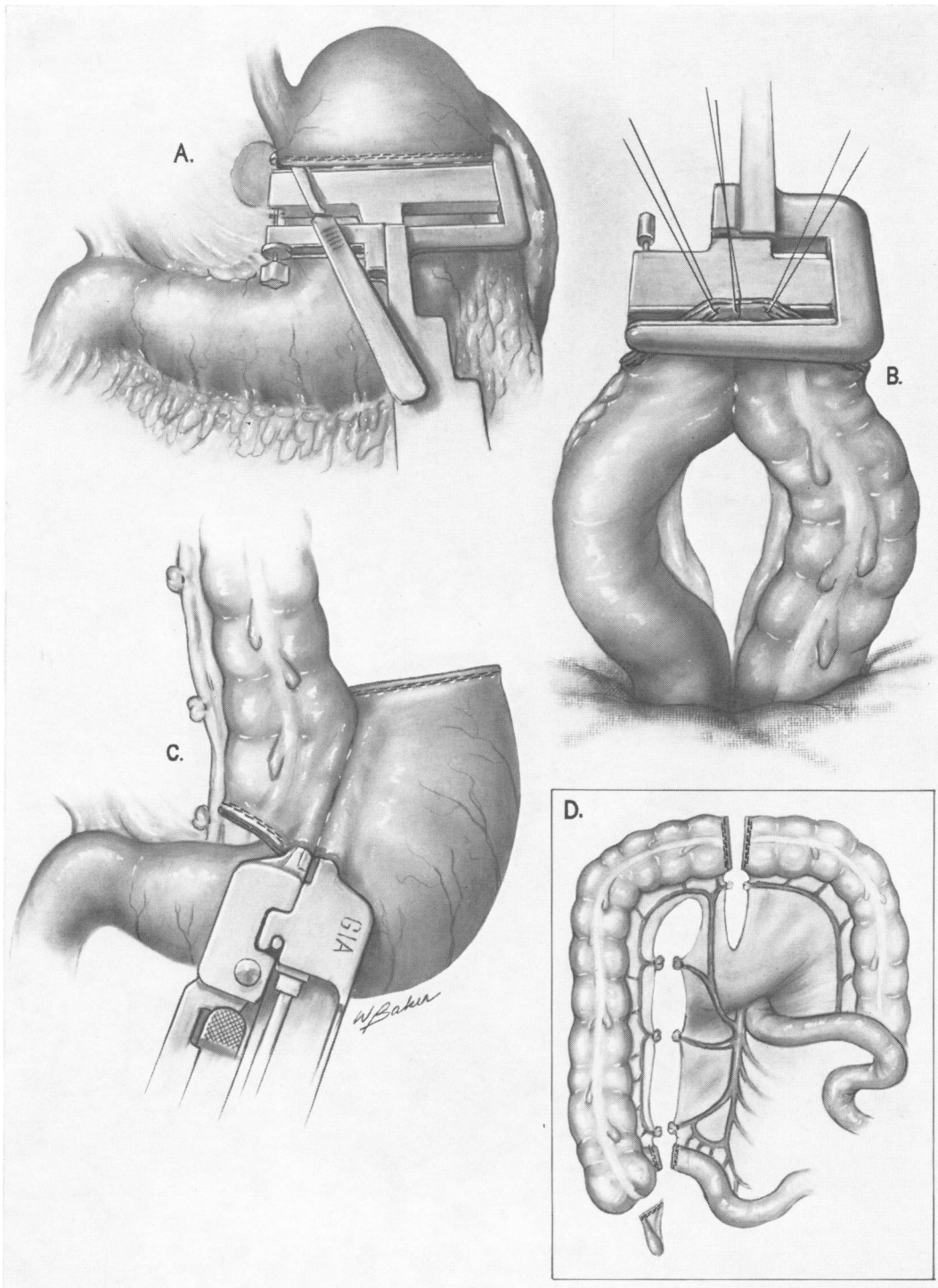
Total Gastrectomy or Esophagectomy (Fig. 10)

The duodenum is stapled with the TA-55 in the ordinary way. The reconstruction can be performed in as many ways with the GIA and TA instruments as it can be manually. If the esophagus has been stapled and transected, the segment to be anastomosed, whether Roux Y of jejunum, jejunal loop or isolated colon, can be brought up along the esophagus. One limb of the GIA is inserted in the esophagus through an amputated corner of the stapled closure, and the other limb is inserted into the bowel segment to be anastomosed, from an appropriate distance below the proximal end of that segment. Once more one is left with a single opening resulting from the division of the septum between the two stab wounds, and closure can be manual and inverting, or with the TA and everting. We have performed this proximal anastomosis satisfactorily in this manner, both in the chest and in the neck. It has been our experience that in the neck anastomoses up to the pharynx, and in the chest anastomoses done from below at the upper limit of accessibility through a given incision, are more readily performed instrumentally than manually. At the lower end anastomosis of the colon to the stomach, or of jejunum-to-jejunum for Roux Y is performed in the obvious way with the GIA, and closure of the stab wound with a TA. By the same token, if a loop esophago-jejunostomy has been performed, the Braun's loop entero-enterostomy is performed with the GIA and a TA closure of the stab wound. We have been impressed by the freedom of these anastomoses from inversion or constriction and by the speed of their accomplishment in these long operations.

Gastric Substitutes

While we have not ourselves employed the GIA for the construction of compound

FIG. 10. *Esophagogastrectomy.* The principles of the resection and reconstruction illustrated apply, with the obvious specific modifications, to various gastroesophageal resections and reconstructions. (A) The stomach is stapled with two applications of the TA-90 and divided between the edge of the instrument at the second application and the suture line from the first application. (B) The right colon has been isolated (as in D), a corner of the stapled end of ileum, left, and colon, right, excised, the prongs of the GIA inserted through the two openings thus created, the anastomosis formed with the GIA and completed by mucosa-to-mucosa closure of the fused stab wounds using the TA-55 as shown in B. Fig. 11—*Resection and Functional End-to-End Anastomosis.* (C) A corner of the distal staple closure of the colon has been cut away, a stab wound made in the stomach and the cologastrostomy has just been performed with the GIA after which the opening left by the GIA is closed mucosa-to-mucosa with a single application of the TA instrument.



intestinal loops for gastric reservoirs or for treatment of the dumping syndrome along the lines of those recommended by Lawrence,[2] Woodward,[13] Poth,[3] Herrington,[1] and others, the GIA would seem ideally suited for these procedures.

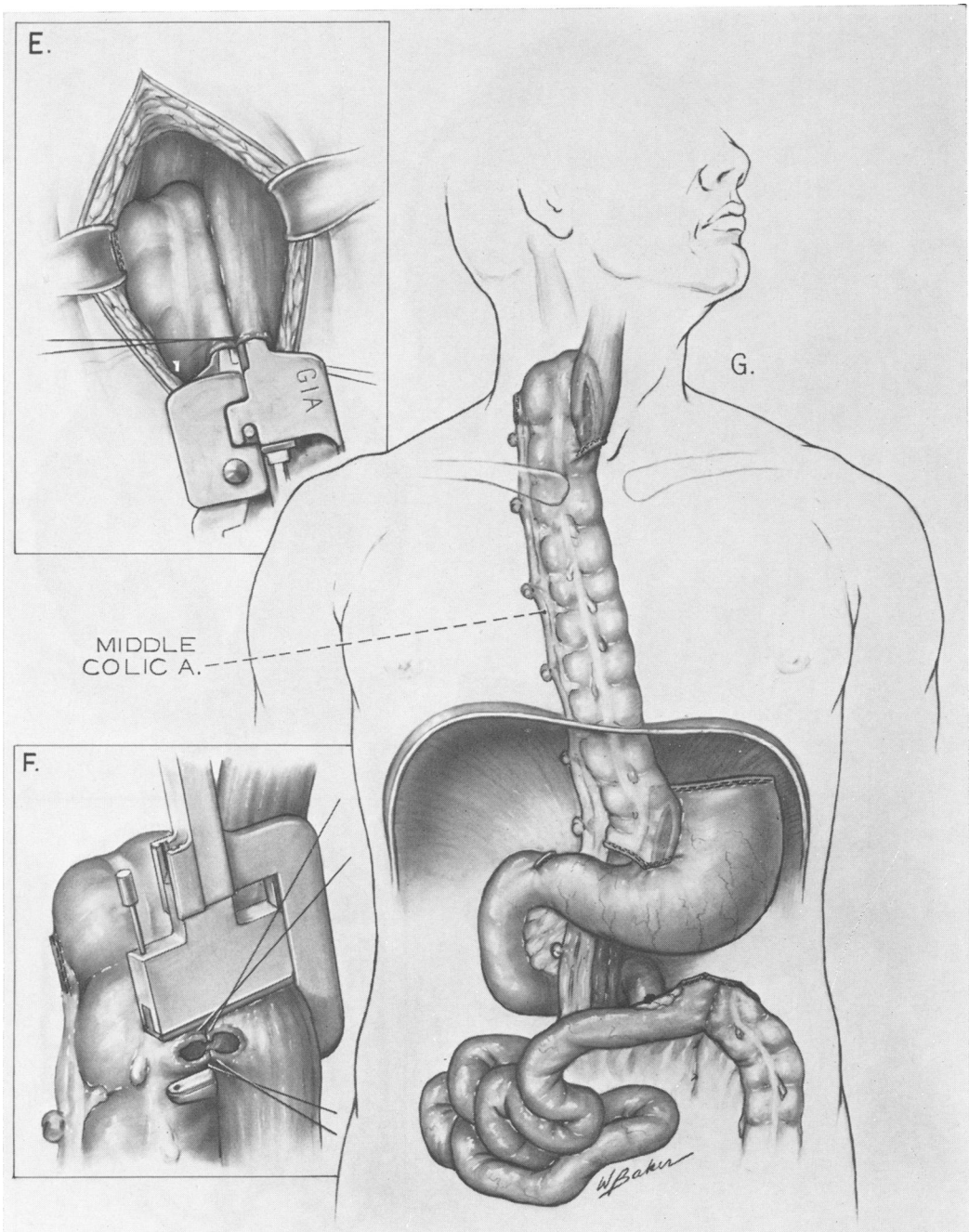


FIG. 10E. A stab wound has been made at the appropriate distance from the cephalad end of the cecum, and a corresponding stab wound made in the esophagus, the distal portion of which is hidden by the GIA instrument. Note the stapled closure of the ileal stump. (F) Shows the special technic for closure of the combined stab wounds left by the GIA, and closure of the esophagus. The TA-55 is applied obliquely and the stapling and excision of the excess proceeds in the usual fashion. (G) Shows the completed result. The colon has been transected and anastomosed, the stomach and esophagus divided, the colon anastomosed to the esophagus and to the stomach and Heineke-Mikulicz pyloroplasty performed, all with staples. The esophagocolostomy and the cologastrostomy are serosa-to-serosa anastomoses, with mucosa-to-mucosa closures of the stab wounds. The ileocolostomy is serosa-to-serosa but the cut ends of ileum and colon have been closed mucosa-to-mucosa.

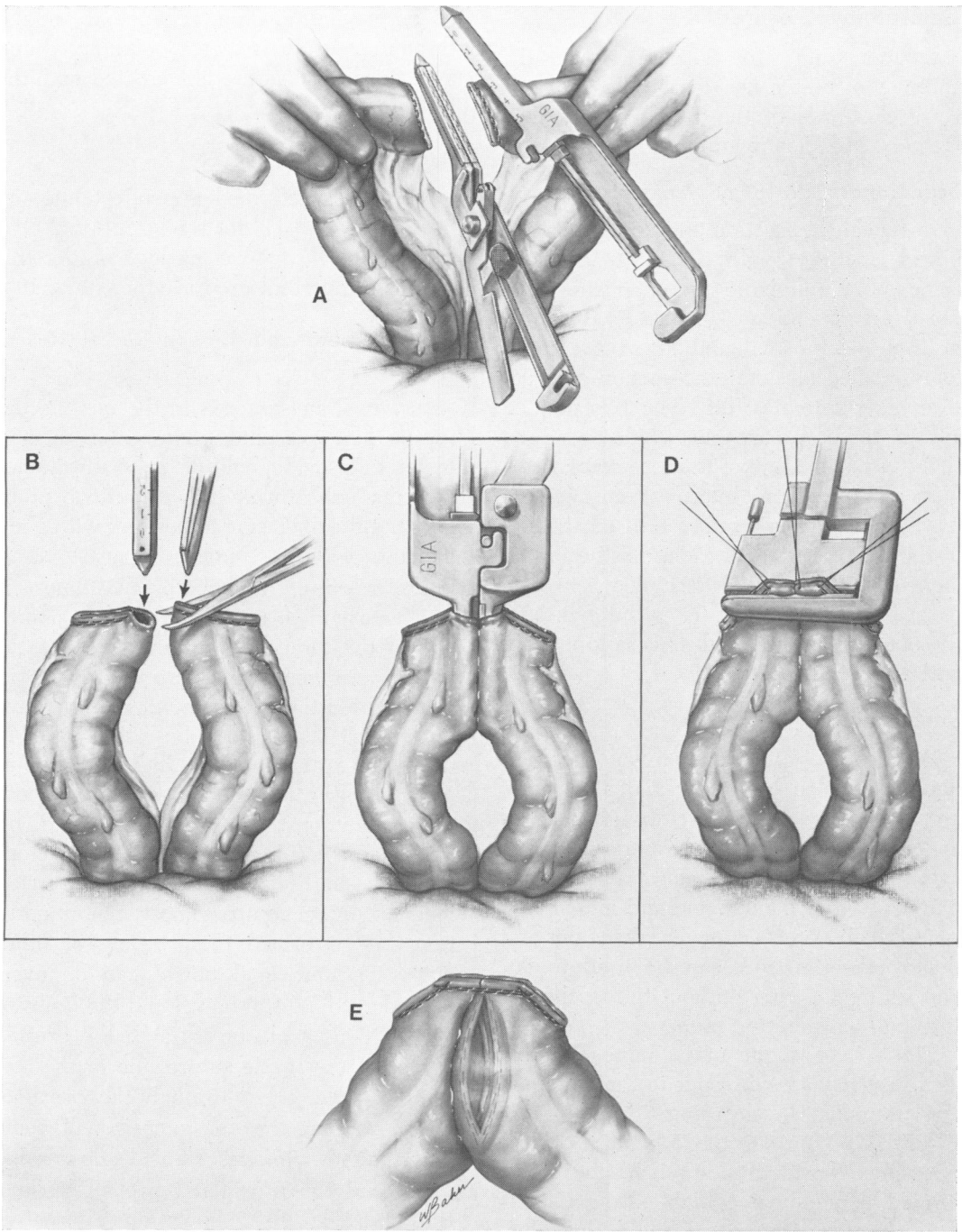


FIG. 11. *Resection and Functional End to End Anastomosis of Bowel.* (A) One limb of the GIA is inserted through the mesentery next to the bowel wall and the other across the antimesenteric border of the bowel. When the instrument halves are mated and locked, and the instrument activated, the bowel is divided, leaving the two ends closed with a double staggered staple line. (B) A corner of each stapled closure is excised. (C) The prongs of the GIA instrument inserted. Activation of the instrument divides the spur or common wall between the two loops and places a double staggered staple line on either side of the division of the apposed walls. (D) The single opening remaining when the GIA instrument is withdrawn is closed mucosa-to-mucosa with the TA instrument. (E) The final anastomosis (shown in transparency), the mucosa-to-mucosa closure of the two original bowel ends, at either side, and of the stab wound across the top, showing the overlapping staple suture lines.

Enterotomy Closure

Duodenotomy, for exploration of the ampulla of Vater has lent itself to transverse closure with the TA-55 just as in a Heineke-Mikulicz pyloroplasty.

Functional End-toEnd Anastomosis

In bowel, transection and anastomosis of bowel is always with the GIA. We have come more and more to prefer the functional end-to-end anastomosis [10] as shown in Figure 11 for small and large bowel anastomoses, ileocolostomies, resection and closure of colostomies, etc. The two stapled ends of the bowel are placed side-by-side in shotgun fashion, apposing bare serosal surfaces and preventing interposition of mesentery. Adjacent corners are excised, a limb of the GIA inserted in each and the instrument driven home, performing the anastomosis. The instrument is withdrawn and the opening for it closed mucosa-to-mucosa with the TA.

Spur Division

We do not, ourselves, employ Mikulicz' double barreled colostomy and, if we did, are inclined to believe we would resect it and perform a formal anastomosis. However, if the spur has been properly prepared, i.e., long enough and anti-mesenteric, —and the bowel is no longer edematous and thickened,—the GIA can be used to cut and suture the spur without taking the patient to the operating room.

The GIA has one of its more effective uses in division of the spur in the Duhamel operation for Hirschsprung's disease (Fig. 12). We prefer [11, 12] the Martin modification. Once bowel anastomosis has been performed manually one limb of the GIA is inserted in the rectum and one in the colon, either from below, through the anus, or from above through the proximal end of the rectum and a stab wound in the colon. In older children it may be necessary to do this both from above and from below. The opening at the upper end is then closed manually. The inelegant and inferior method of employing crushing clamps to slough through the spur is thereby eliminated and a clean surgical suture line created with the instrument.

Appendectomy

We have performed appendectomy, *"en passant,"* with LDS for the vessels and GIA for the bowel, but we hardly consider this to be an important use for either (Fig. 10).

Rectosigmoid and Lower Rectal Resection

In bowel anastomoses in the rectum, the use of the two technics figured has seemed to us to provide considerable advantages over manual suturing although this is probably not the operation to perform with one's first use of the instrument for anastomosis.

The everting, triangulating anastomosis is satisfactory in this area and the eversion of two of the three lines of sutures causes us no concern here. It is also acceptable in colon within the abdomen whereas we have not used it in the small bowel, in part because our experimental studies to this point suggest that the everted flanges of mucosa invite adhesions. The functional end-to-end anastomosis has been extremely satisfactory clinically, and leaves only a single everted flange. Low rectal anastomosis can, in addition, be performed in a variety of other ways. The proximal bowel can be overlapped on the distal bowel and the limbs of the GIA inserted one through the excised corner of the staple suture line in the rectum, and the other through the proximal bowel so that the anastomosis will come down almost to the stapled closed-over distal end the proximal bowel. The illustration (Fig. 13) shows an alternative method which is easy and effective.

Discussion

The dependability and versatility of the LDS can hardly be over stressed. We have used it, for instance, for all tissues within the abdomen, in a radical abdomino-perineal

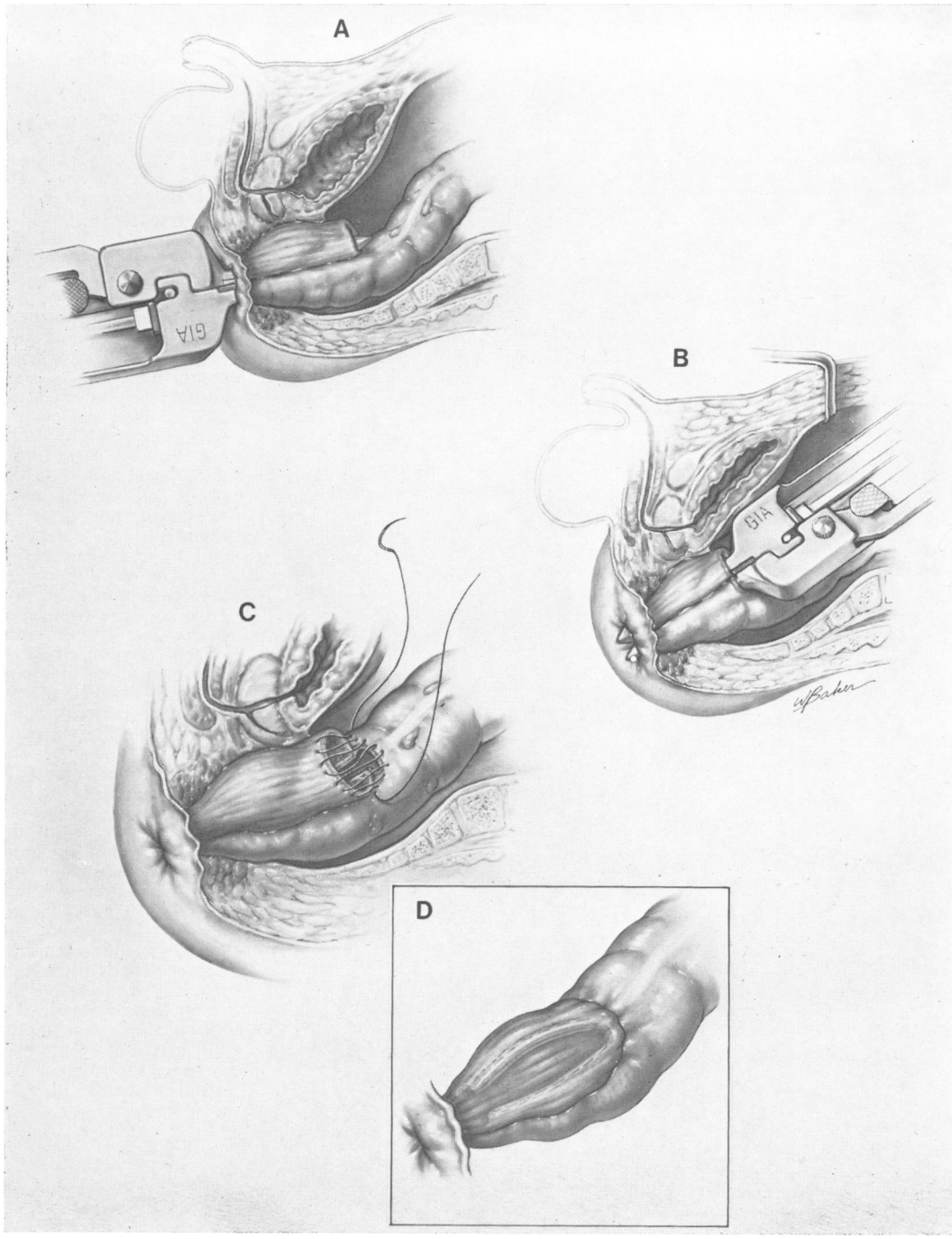


FIG. 12. *Duhamel Procedure for Hirschsprung's Disease.* (A) The resection has been completed and the proximal ganglionic colon has been anastomosed to the rectum by manual sutures. One blade of the GIA is shown passing through the anus and up the original rectum, the other through the anastomosis just described into the colon lying behind the rectum. (B) The same thing can be accomplished in the reverse direction by placing the limbs of the GIA from above, one limb through the rectum and the other through the colon through a stab wound. (C) In either case the result is a complete division of the entire septum between the rectum and the colon and the remaining opening is closed manually with sutures. (D) Shows the completed procedure with the anastomosis showing in transparency. The spur, the principal technical problem in the Duhamel operation does not exist and the need for applying crushing clamps to the septum, until sloughing allows them to fall away, has been eliminated.

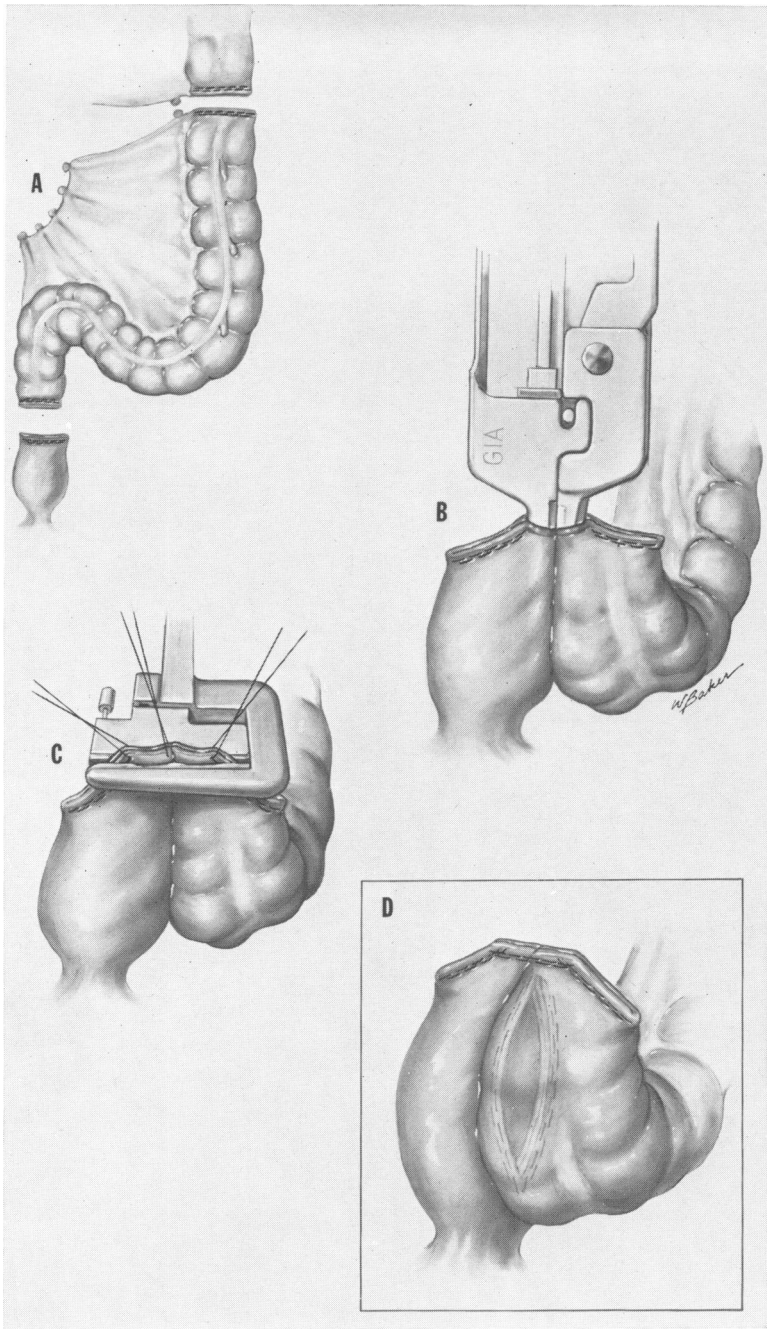


FIG. 13. Anterior resection of the rectum. (A) The mesentery is mobilized with the LDS and the proximal bowel transected with the GIA. If the distal limit of the resection is to be low it will not be possible to employ the GIA for transection and stapling of the distal end and one may then staple the rectal stump with a TA-55 securing the bowel proximal to this with an ordinary clamp. (B) turning the end of the proximal bowel down into the pelvis and back up again as shown, one performs essentially a functional end to end anastomosis. (C) The opening left by the withdrawal of the GIA is stapled mucosa-to-mucosa. (D) The completed reconstruction is seen. A variety of modifications have been employed to perform a low rectal anastomosis with these instruments. The most obvious is that in which the distal end of the proximal segment is passed down into the pelvis beyond the stump of the distal segment and the limbs of the GIA inserted, (1) into the corner of the rectum and (2) into the colon, the appropriate distance from the end of the colon, the result being a side-to-side anastomosis extending the full length of the overlap between the proximal and distal segments.

resection with pan-hysterectomy, suturing in addition only the uterine vessels. Its use in omentum, mesentery, etc. achieves in a single step what is normally done by applying two clamps, dividing the tissue between them with knife or scissors and ligating both ends.

We are inclined to believe that with the development of stapling instruments, such as those described, we are at the threshold

of an era of increasing use of more or less mechanized methods for gastrointestinal surgery. The instruments described are simple to use, require less manipulation of tissues and less trauma to them than is involved in manual suture, minimize soiling and bleeding. The application of the TA 90 to the stomach, for instance, places 33 sutures at one time, eliminating at a minimum, 33 passages of needle, with the attendant pulling and hauling of the suture through the tissue and the repeated handling of bowel with forceps. For some operations and for some operators the saving in time may be substantial. Surgeons are craftsmen and as such almost automatically resent the imputation that a machine may do as well or better what they love to do manually. However, our experience with the devices herein discussed leads us to believe that while there will always be a place for skill, artistry and manual dexterity in surgery, we would no more go back to old methods of transection and suture of bowel as a routine than we would go back to the taking of split thickness skin grafts with a free hand knife, as a routine. Obviously situations will occur to which the instruments will not adapt themselves, and one will have to rely upon manual suture. Equally obviously, one must learn to use these instruments as one would learn to use a needle and thread. Nor will these instruments make a virtuoso out of a tyro, or make a difficult operation safe for the ill-trained. We are convinced they do permit competent surgeons to operate more effectively, for the benefit of their patients.

The probability is, indeed, that these instruments will be developed, advanced and modified in ways not yet foreseen and obviously that others, possibly based on totally different principles, will presently be devised. We have been impressed by the ingenuity of surgeons in adapting the instruments to special procedures and uses which had not been anticipated or envisioned. This presentation does not cover a number of isolated instances of the solution of special problems with these instruments and undoubtedly many more will appear with time.

Summary

We describe the technics of use in various operative procedures upon the gastrointestinal tract of a variety of stapling instruments for (1) simultaneous double ligation and division of vessels, (2) division and simultaneous closure of both ends of intestine (3) closure of cut ends of tangential incisions in portions of the gastrointestinal tract, (4) performance of a variety of anastomotic reconstructions of the gastrointestinal tract.

We consider the precision of suture and division and the decrease in trauma to be the principal advantage of these instruments, with their associated prevention of bleeding and soiling, and resultant faster healing. However we are not unmindful of the time saving involved.

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Discussion

Dr. Walker Reynolds, Jr. (Anniston): Dr. Ravitch and Dr. Steichen have done the pioneer work in this field which led me to my interest in it some 3 years ago. I have now done some 45 procedures using these instruments.

Before I present some other technics, in addition to those Dr. Ravitch has shown, I would like to pose one question for answer later, and that is: When do they use secondary sutures to reinforce the staple line?

This is a most versatile instrument, the GIA, [slide] and I would like to show you the simple operation of appendectomy. It is a large instrument for a small appendage. However, you get a bonus. You get the mesoappendix with it. However, you should not depend on getting the appendiceal artery. It should be ligated individually.

[Slide] This shows the appendix being severed at the appendicocecal junction with a very clean cut; no spillage, no chance for stump syndrome.

A number of Lembert sutures have been added. This shows too many. Only two or three are needed and you have a very neat appendectomy. I have done this in 13 patients. I do not do it all the time. It is an exceptionally good instrument to do a Meckels' diverticulum of which I have done one.

[Slide] You have heard the reverse gastric tube discussed, and you have heard all about the different ways to stop the dumping syndrome. I have recently used a new method to prevent the dumping syndrome by creating a gastric tube. I stumbled on this accidentally in trying to remove a very large, massive adenocarcinoma in a 60-year-old man, a carcinoma of the stomach. By using my GIA stapler to cut my pattern, I ended up with a tube on the greater curvature, and had to transect the duodenum, so I decided to do a Billroth I. The patient did so well, there was no dumping and he gained weight (I saw him last week). Fifteen months after operation he weighs 32 pounds more than he did at time of surgery, and is doing well from the standpoint of the GI tract—no dumping whatsoever.

So with this in mind we decided to go into peptic ulcer disease, with its complications. The next slide [slide]—is an actual drawing made of the first patient. This was a drawing of his actual x-ray film before operation. I went to a point midway on the greater curvature, and went 5 cm. down the length of our GIA stapler and decided that I would make a 3 cm. tube.

[Slide] This shows the actual tube being formed on the greater curvature side, with a 3 cm. measurement, with forefinger inserted to be sure I had ample room.

[Slide] This shows the same thing looking at it with the staple line going on up the lesser curvature, which I will reinforce. This GIA has a short staple—as Dr. Ravitch mentioned, and you have to overlay when you are working in the stomach.

[Slide] We are now firing the GIA stapler superiorly toward the left gastric artery. We have tried to follow, before we started this, the antrectomy-vagotomy described by Scott, Sawyers and Herrington, and this, you might say, is a modification of their operation.

[Slide] This view looks down from above, but I also use a gastrojejunal catheter. I do not think I would try it without the catheter, because they must be tube fed after operation, and I like to have suction in case vagus atony occurs.

[Slide] This shows the completed procedure, and the next will show [slide] the anatomosis. This is a closeup of the stomach tube on the right, the duodenum on the left, coming on into a conventional closure.